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Composition and abundance of microcrustacean fauna in the Upper Reservoir (Hídvégi-tó) of the Kis-Balaton

by
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Abstract: The first stage of the Kis-Balaton Protective System has been operating since 1985. It was constructed with the aim to inhibit or reverse the deterioration of water quality in Lake Balaton. From 1985 through 1989, 32 cladoceran and 13 copepod species were recorded from the various habitats of it (plankton, mud surface, phytal). On the basis of species composition of planktonic crustaceans five water quality regions could be distinguished in this impounded water between 1985 and 1987, while in 1989 only 3. In the samples collected from mud surface by means of funnel traps only few species were found, the copepod species *Acanthocyclops robustus* f. *limnetica* being also dominant in the plankton was the most frequent. Along the longitudinal axis of this lake the number of individuals diminished in southern direction. The results showed that the lake is still young, and the assemblages of planktonic and mudliving crustaceans are not constant.
Key words: Kis-Balaton Protective System, Cladocera, Copepoda, number of individuals, biomass, water quality region.

Introduction

Attention was called to the deterioration of water quality in Lake Balaton as early as in the fifties by Sebestyén (1953). Algae appeared in increasingly greater amounts, areas covered with aquatic macrophytes diminished, and planktonic eutrophication intensified. The first spectacular sign of these changes was the algal bloom in the Bay of Keszthely in 1965, which in the subsequent years has frequently recurred.

Water quality studies revealed that 35-40% of the plant nutrients in Lake Balaton originates from the catchment area of the River Zala, and enriches the Bay of Keszthely (Joó & Lotz 1980). That is why the water quality has most drastically deteriorated here. To slow down or stop this process, the first stage of the Kis-Balaton Protective System was constructed on the lower section of the River Zala in 1985, and was named lake Hídvégi-tó. This lake has the following dimensions: area = 18 km^2, volume = 21 million m^3, average depth = 1.14 m, average retention time = 30 days (Joó *et al.* 1987). The crustacean fauna has also been systematically investigated here since 1985. The results of this 5-year study are presented in this paper.

The results of studies carried out from 1985 to 1990 were summarized by Pomogyi (1991) in a comprehensive work. The most important conclusions drawn from the qualitative and quantitative studies on the rotatorian and crustacean plankton in this lake constitute one of the chapters (Gulyás 1991) of this work. The changes and growth of planktonic and benthic biocenoses in relation to water quality are published by Csányi *et al.* (1989). Other studies on these groups of organisms have not been published so far.

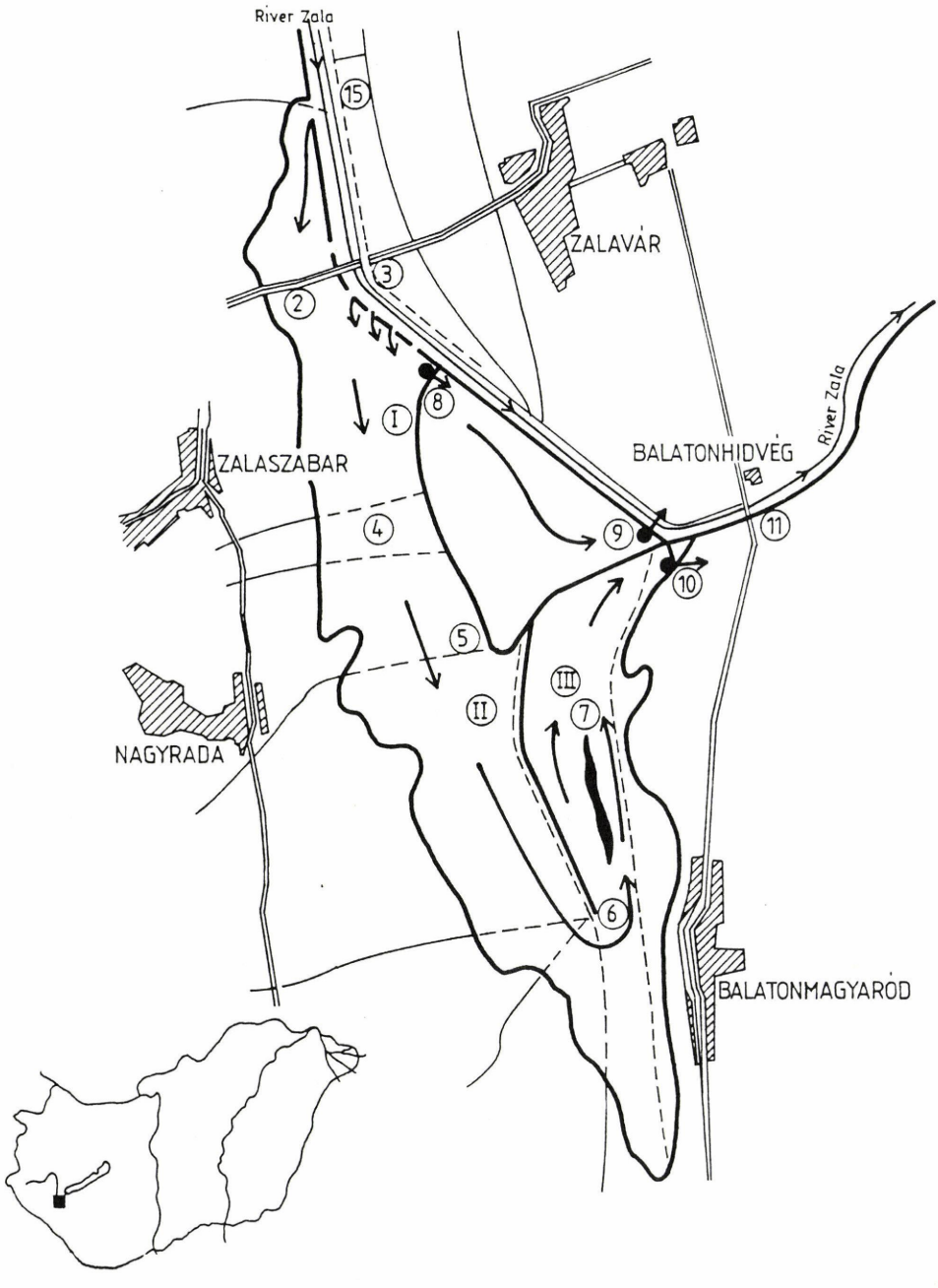

Fig. 1. Sampling sites in the Hídvégi-tó. Numbers indicate sampling sites (2-15 for planktonic and I-III for epibenthic crustaceans)

Objectives

The aim of the qualitative and quantitative studies on cladocerans and copepods inhabiting the open water and mud surface in this lake was to find out·

- which species of these animal groups occur there,
- how the assemblages of these animals change in space and time,
- whether it is possible to distinguish different water quality regions in the lake on the basis of the occurrence of species,
- how cladoceran and copepod abundance and biomass change in the various water quality regions of the lake.

To obtain answer to the aforementioned questions, these two groups were systematically studied, simultaneously with the chemical and phytoplankton investigations, at 11 points of the lake from 1985 through 1989. The species occurring at these points as well as their number of individuals and biomass were determined. During another series of studies qualitative samples were collected from the lake at about 30-40 points on two occasions in 1985, and on one occasion in 1989. Crustacen biomass and its changes during these five years were evaluated on the basis of presences and absences of species.

Material and methods

For the analysis of crustacean plankton water samples were collected from the surface water layer. From each sample 20-50 liter was filtered through a plankton net of 70 μm mesh. The filtrates were conserved in situ with formaldehyde to a final concentration of 4%. Quantitative analyses were performed in the counting chambers of 5 ml of an Utermöhl inverse microscope.

From the mud surface, the animals were collected with funnel traps. The method is based on the fact the vertically migrating crustaceans actively get into the collecting bottle. This method can be very effectively used for collecting quantitatively various animal groups living on mud surface (mainly Cladocera and Copepoda) (Whiteside & Williams 1975, Whiteside & Lindegaard 1980). Each trap consisted of three glass funnels of 10 cm diameter, which were connected with a bottle by means of a plexi plate. The traps were set up at three points along the longitudinal axis of the lake, using three traps at each point. The traps were placed out in the afternoon and removed next morning. Thus, collectings were performed for at least 18 hours with this device. The sampling sites are indicated in Fig. 1.

Results

Planktonic communities

Qualitative studies

Following the filling of the Hídvégi-tó, enormous mass productions of two cladocerans, *Daphnia magna* and *Daphnia longispina* could be observed during summer 1985, which lasted until the middle of July. Later, these species were not so numerous. Besides the aforementioned two species, *Bosmina longirostris, Chydorus sphaericus, Acanthocyclops robustus, Eucyclops serrulatus, Mesocyclops leuckarti* and *Thermocyclops crassus* were also frequent in the plankton samples.

Simultaneously with *Daphnia* mass production, water bloom caused by the blue-green alga *Aphanisomenon flos-aquae* also occurred, and in addition almost impenetrable stands of aquatic macrophytes covered a great part of the lake, among which the water was clear down to the bottom. It is also an interesting observation, that during that time species number, abundance as well as biomass of Rotatoria were extremely small.

On the basis of species found in the water samples taken at about 30 sampling points, the lake could be divided into well separable water quality regions. Using the similarity dendograms obtained by cluster analyses, the following water quality regions could be distinquished (Fig. 2):

- the inlet section of the River Zala, and the River Zala at the bridge of Zalavár,
- the section of the lake between the Zalavár road and the millstream at Rada,
- the cassette,
- the southern part of the lake and the surroundings at the outlet,
- the area of the islet "Kányavári-sziget",
- the River Zala at the bridge of Balatonhídvég (Fig. 3).

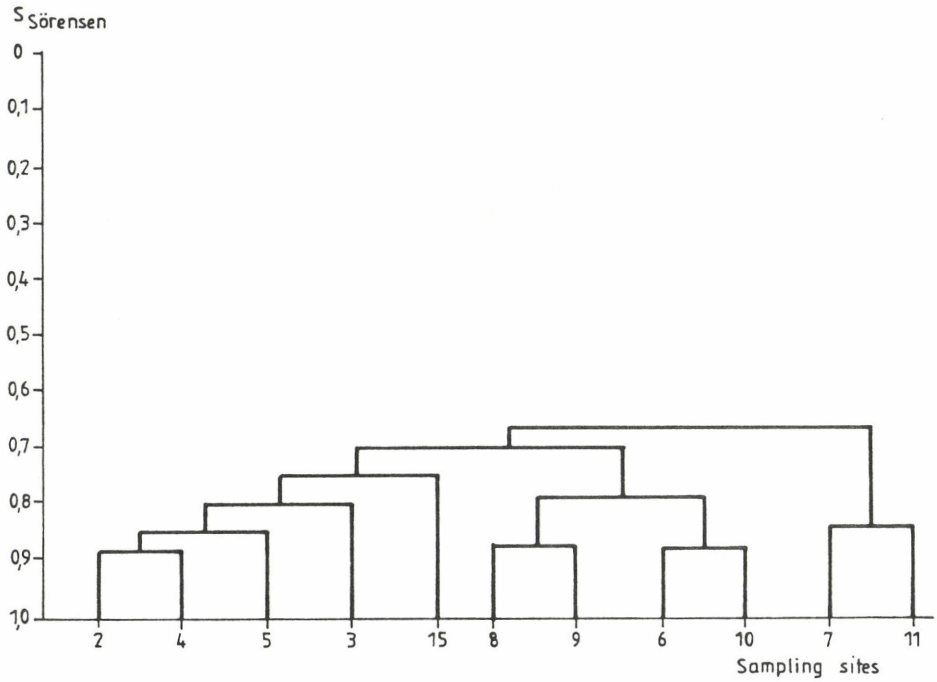

Fig. 2. Clusters of sampling sites based on the coexistential pattern of planktonic crustaceans (Sorensen-index)

The analysis of the regional distribution of planktonic crustaceans showed that the central parts of the lake (the brook "Szabari patak", the mill-stream of Rada) were most rich in cladoceran species, while in the southern part of the lake the number of copepod species was great.

On the basis of results obtained during phyto- and zooplankton studies and water chemical analyses performed in 1985, 11 sampling places were allocated, at which in the following years systematic studies were carried out.

In 1986, the dominance of rotifers was characteristic in the whole area of the lake. Cladocerans were sporadical on each occasion and at each place. In the southern parts overgrown with vegetation and in the vicinity of the islet "Kányavári sziget" the diversity of zooplankton was the greatest (sampling places 6 and 7).

Metaphytic species were the most frequent there (e.g. *Alonella excisa, Ceriodaphnia quadrangula, Disparalona rostrata, Macrothrix hirsuticornis, Pleuroxus aduncus, Eucyclops serrulatus, Macrocyclops albidus, Thermocyclops crassus*). In the water flowing out from the cassette and in the central part of the lake *Acanthocyclops robustus* f. *limnetica* and *Mesocyclops leuckarti* formed great populations during summer.

In the following year great stands of aquatic macrophytes were not produced in the middle part of the lake. The majority of zooplankton communities were made up on each occasion and in every place by rotifers. Species number of crustaceans, the diversity of their communities markedly decreased even in the southern regions of the lake. As a result of the great flood which started in early August and lasted for about three weeks, the water quality regions distinguished previously completely disappeared. Only the cassette (sampling point 8) formed an exception to that, in which the abundance of zooplankton remained unchanged because of the longer retention time.

In 1988, planktonic crustacean communities exhibited essential changes in species composition. The number of species continued to decrease. At the same time, however, number of individuals became many times greater. In most cases and in most places, the dominance of species typical of eutrophic standing waters and fishponds could be found: *Bosmina longirostris, Chydorus sphaericus, Diaphanosoma brachyurum, Moina micrura, Acanthocyclops robustus* f. *limnetica, Mesocyclops leuckarti, Thermocyclops crassus, Thermocyclops oithonoides*). *Moina micrura* occurred only sporadically in the previous years, but from this year it has become a characteristic cladoceran species of the Hídvégi-tó. It is also worth mentioning here that *Eudiaptomus gracilis* has been frequently found in this lake, and often formed great populations in it.

The mosaic nature of the lake observed earlier could not be detected in this year. It is interesting that during the bloom of the blue-green alga *Microcystis aeruginosa* during the drought in July and August, the density of planktonic crustacean communities did not diminish.

In 1989, collectings were repeated in the whole lake. These collectings had the special aim to determine water quality. In that period mass productions of the blue-green algae *Microcystis, Aphanisomenon* occurred in the whole reservoir. On the basis of species compositions of planktonic crustacen communities, the lake proved to be almost homogenous at that time. The earlier water quality regions ceased to exist (Fig. 4). The number of true euplanktonic species (*Bosmina longirostris, Daphnia longispina, Daphnia hyalina, Diaphanosoma brachyurum, Leptodora kindtii, Eudiaptomus gracilis, Cyclops vicinus, Mesocyclops leuckarti, Thermocyclops crassus, Thermocyclops oithonoides*) has practically not changed compared to previous years. At the same time, however, several species were recovered from the plankton samples, which are inhabitants of the littoral of shallow waters and the waters among the vegetation (*Disparalona rostrata, Iliocryptus sordidus, Leydigia leydigi, Oxyurella tenuicaudis, Eucyclops serrulatus, Macrocyclops albidus*). The greatest changes took place in the southern part of the lake. In the preceding years the number of individuals decreased markedly, species numbers increased and species not found elsewhere were frequently recorded. In this year of examination, there was no decrease in abundance, and the dominant species of communities were identical with those found in the vicinity of the brook "Szabari patak" and the mill stream of Rada.

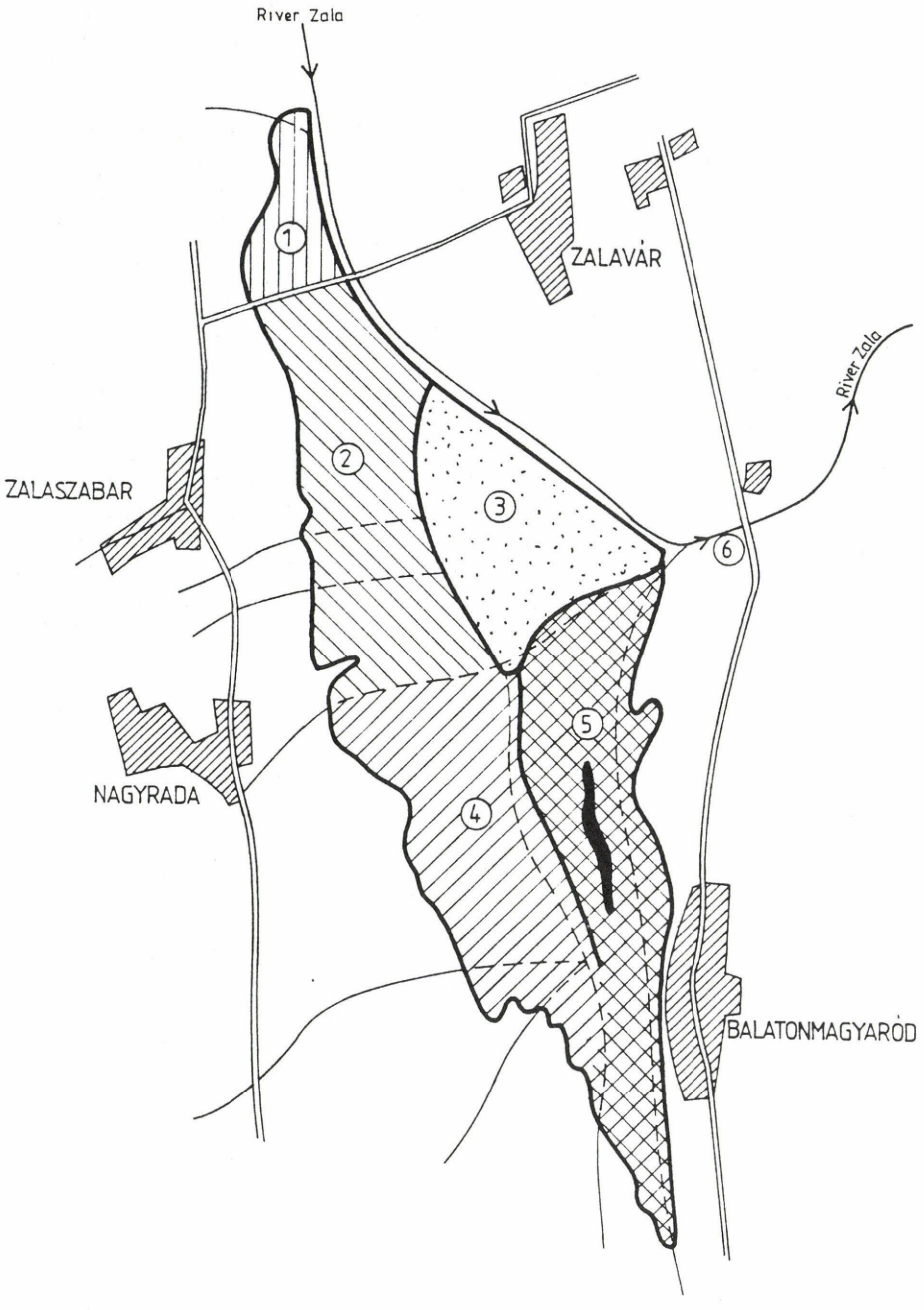

Fig. 3. Topographical classification of the Hídvégi-tó based on water quality (1985-1987)

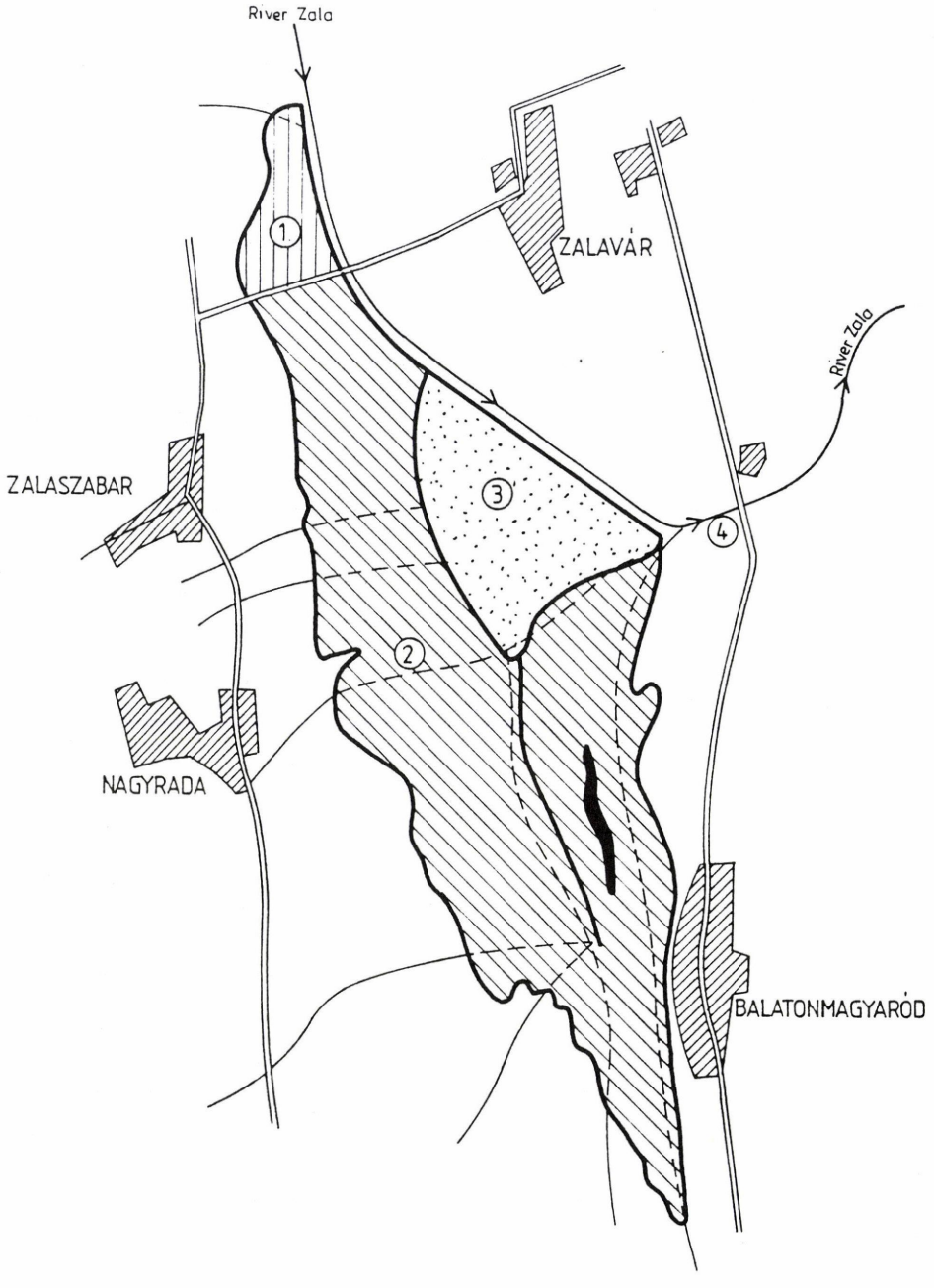

Fig. 4. Topographical classification of the Hídvégi-tó based on water quality (1988-1989)

Species compositions of planktonic crustacean communities in the cassette differed from those in the external reservoir space. In the latter populations of *Acanthocyclops robustus* f. *limnetica* and *Moina micrura* exhibited great densities in early spring and during summer.

On the basis of the analyses on crustaceans performed in 1988-89 the first stage of the Kis-Balaton Protective System can be divided into the following water quality regions:

- the inlet section of the River Zala and the stream "Bárándi víz",
- the external reservoir space,
- the cassette,
- that section of the River Zala, which collects the waters flowing from the external reservoir space and the cassette (Fig. 4).

Quantitative studies

The results of quantitative studies are given in individuum/dm^3 unit, and those of biomass studies in wet weight mg/m^3 dimension.

In the water of the River Zala entering the Hídvégi-tó, both the number of individuals and biomass of cladocerans and copepods were small. During the five-year studies their densities were 1-28 i/dm^3 and their biomass varied between 1.2 and 74.7 mg/m^3.

Following the filling of the lake, values for number of individuals and biomass of *Daphnia magna* and *Daphnia longispina* were 24-327 i/dm^3 resp. 4882-75265 mg/m^3 in the central part of it (sampling places 4-6) and on one occasion in its southern part (sampling place 7) during summer 1986. Such great zooplankton mass productions did not occur in the following years.

In 1986-88 the greatest planktonic crustacean populations were generally found in the central parts of the lake (sampling places 4 and 5). These communities were almost without exception made up by the individuals of *Acanthocyclops robustus* f. *limnetica* and *Moina micrura*. The latter species appeared in greater quantity in 1988. During July and August of the same year, its mass production was registered in the environment of sampling place 4 (88 i/dm^3. biomass 13689.6 mg/m^3). On some occasions the individuals of *Acanthocyclops* were also numerous (max. 239 i/dm^3, biomass = 2041.2 mg/m^3).

In the cassette, number of individuals and biomass of species were generally identical with those found in the central part of the lake.

In 1988, the yearly average number of individuals pro dm^3 of Cladocera and Copepoda were computed for the various parts of the lake. The values obtained varied considerably. In the inflowing River Zala, in the vicinity of sampling places 2 and 3 this value was 21, in the middle part of the lake (sampling places 4, 5, 8) 133, in the southern part of the lake (sampling places 6, 7) 35, and at the outlet 92. The value for the whole storage space averaged 84.

The values well illustrate the essential structural changes of planktonic crustacean communities in the lake.

In 1989, the planktonic crustacean communities attained great dimension not only in the middle part of the lake, but in the southern part, as well (sampling places 6, 7). The differences established earlier between the various parts of the lake ceased to exist.

Number of individuals did not even diminish during the green-algal blooms in summer and fall, or during the *Diatoma* bloom in spring. Compared to previous years, the amount of planktonic crustaceans greatly increased as shown by the number of individuals and biomass maxima for the various parts of the lake:

- the River Zala at the inlet: 33 i/dm^3, 88 mg/m^3,
- in the vicinity of sampling place 2: 92 i/dm^3, 1223.5 mg/m^3,
- in the vicinity of sampling places 4 and 5: 197 i/dm^3, 4106.4 mg/m^3,
- in the vicinity of sampling places 6 and 7: 239 i/dm^3, 6889.2 mg/m^3,
- at the outlet of the Hídvégi-tó: 166 i/dm^3, 4490.5 mg/m^3.

Epibenthic communities

In July 1987, besides a few cladocerans (e.g. *Bosmina longirostris, Moina micrura, Alona rectangula*), only one copepod species *Acanthocyclops robustus* f. *limnetica* was found in great abundance in the samples collected with funnel traps in the northern part of the lake (Station I) (Fig. 1). In contrast, at Station II *Moina micrura* dominated among the few cladocerans, but the individuals of *A. robustus* f. *limnetica* constituted the greatest part of the sample. It is interesting that in that sample *Iliocryptus sordidus* was also represented by one specimen. The sample collected at Station III had an entirely different species composition, also containing such cladoceran species as *Ceriodaphnia quadrangula, Chydorus sphaericus.* Besides the unvariably dominant *A. robustus* f. *limnetica*, individuals of *Megacyclops viridis* and *Thermocyclops crassus* were also recorded.

The samples collected in October 1987 slightly differed from the summer ones, since fewer species were found in the traps. The greatest number of species occurred at Station III.

During the summer 1988, collections were made on three occasions. In July collections were made at Stations I and II. The species compositions of cladoceran assemblages were similar, *Moina micrura, Alona rectangula* and *Alona affinis* occurring most frequently. Of the Copepoda, *Acanthocyclops robustus* f. *limnetica* was dominant at both stations, but at Station II besides *Cyclops vicinus* two other species (*Eucyclops serrulatus, Megacyclops viridis)* also occurred.

In July, samples were taken at all of the three stations, and in them *Acanthocyclops robustus* f. *limnetica* was the dominant species, and of the very few cladocerans *Moina micrura* was the most frequent. During August collections were made at Stations I and III. Species richness was higher at Station III. At both stations the massive dominance of *Acanthocyclops robustus* f. *limnetica* was characteristic.

In the course of the series of studies 16 Cladocera and 9 Copepoda species were found in the funnel traps (Table 1). The number of crustacean species ranged from 2 and 8 in the samples. The results obtained in 1988 showed that species number was the greatest in June, ranging from 6 to 7 and 4 to 5 at Stations I and II respectively. In July species numbers decreased, in the samples collected at Stations I, II and III 3-4, 2 and 2-3 species were found respectively. In August, the individuals of 2-3 species made up the cladoceran and copepod assemblages at Station I and III.

Table 1. List of Cladocera and Copepoda species found in funnel traps

Cladocera	Copepoda
Alona affinis	*Acanthocyclops robustus*
Alona rectangula	f. *limnetica*
Alonella excisa	*Cyclops vicinus*
Bosmina longirostris	*Eucyclops serrulatus*
Ceriodaphnia quadrangula	*Eudiaptomus gracilis*
Chydorus sphaericus	*Macrocyclops albidus*
Daphnia longispina	*Megacyclops viridis*
Diaphanosoma brachyurum	*Mesocyclops leuckarti*
Disparalona rostrata	*Thermocyclops crassus*
Dunhevedia crassa	*Thermocyclops dybowsskii*
Graptoleberis testudinaria	
Iliocryptus sordidus	
Leydigia acanthocercoides	
Macrothrix hirsuticornis	
Moina micrura	
Pleuroxus aduncus	
Tretocephala ambigua	

Table 2 shows the quantitative results of collections made by means of funnel traps. The values are expressed in individual/m^2 unit. On each occasion number of individuals were most surprisingly the greatest at Station I. Another rather general feature was the fact that in each sample the density of Copepoda greatly exceeded that of Cladocera. At each station, density of crustaceans living on sediment surface diminished in late summer and during fall.

Table 2. Abundance of epibenthic crustaceans in Hídvégi-tó (ind./m^2)
(I, II and III refer to the collecting sites shown in Fig. 1.)

		1987		1988		
		July	October	June	July	August
I	Cladocera	1083	3057	3723	1486	147
	Copepoda	38517	29151	8692	20243	4773
	Total	40131	32380	22111	23286	5164
II	Cladocera	366	339	403	127	
	Copepoda	26913	2888	1359	1062	
	Total	27895	3269	2378	1854	
III	Cladocera	6808	1194	4151	393	
	Copepoda	23611	4741	7655	2771	
	Total	37484	6030	11901	3450	

The values obtained along the longitudinal axis of the lake were different between 1987 and 1988. In July and October 1987 the smallest number of individuals occurred at Station II in the central part of the lake, and numbers increased again at Station III. In 1988, the abundance was smaller than in the preceding year, and in general a decrease from north to south could be observed.

Discussion

The composition of planktonic crustacean communities has changed considerably in the years following the filling of the lake. The water quality regions distinguished in the first years gradually disappeared. The number of species, and the diversity of species communities decreased. At the same time, individuals of one or other species often formed great populations. During the last two years of these studies *Moina micrura, Bosmina longirostris* and *Acanthocyclops robustus* f. *limnetica* attained great abundance. The other species occurred sporadically (Table 3).

Table 3. Planktonic occurrence of Cladocera and Copepoda species

Cladocera	1985	1986	1987	1988	1989
Alona costata Sars, 1862	+	+			
Alona guttata Sars, 1862	+				
Alona rectangula Sars, 1862	+	+	+	+	+
Alonella excisa (Fischer, 1854)		+	+		
Alonella exigua (Lilljeborg 1853)	+	+			
Bosmina longirostris (O.F.Müller 1785)	+	+	+	+	+
Ceriodaphnia quadrangula (O.F.Müller 1785)	+	+	+	+	+
Chydorus sphaericus (O.F.Müller 1785)	+	+	+	+	+
Daphnia hyalina Leydig, 1860			+	+	+
Daphnia longirostris O.F.Müller 1785	+	+	+	+	+
Daphnia magna Straus, 1820	+				
Diaphanosoma brachyurum (Liévin, 1848)	+	+			+
Disparalona rostrata (Koch, 1841)		+		+	+
Dunhevedia crassa King, 1853	+				
Iliocryptus sordidus (Liévin, 1848)					+
Leydigia leydigi (Schoedler, 1863)					+
Leptodora kindtii (Focke, 1844)					+
Macrothrix hirsuticornis Norman et Brady, 1867	+	+		+	
Moina micrura Kurz, 1874	+	+	+	+	+
Oxyurella tenuicaudis Sars, 1862	+	+			
Pleuroxus aduncus (Jurine, 1820)	+	+	+		
Scapholeberis aurita (Fischer, 1849)	+	+			
Scapholeberis mucronata (O.F.M. 1785)	+	+			+
Simocephalus vetulus (O.F.M. 1776)	+	+			+
Tretocephala ambigua (Lilljeborg, 1900)	+				
Copepoda					
Calanoida					
Eudiaptomus gracilis (Sars, 1863)	+	+	+	+	+
Eudiaptomus vulgaris (Schmeil, 1869)	+	+			
Cyclopoida					
Acanthocyclops robustus f. *limnetica* Petkowski, 1976	+	+	+	+	+
Cyclops strenuus strenuus Fischer, 1851		+	+		+
Cyclops vicinus vicinus Ulianine, 1875	+		+	+	+
Eucyclops serrulatus (Fischer, 1851)	+	+			+
Eucyclops speratus (Lilljeborg , 1901)	+	+	+		
Macrocyclops albidus (Jurine, 1820)	+	+			+
Megacyclops viridis (Jurine, 1820)	+	+	+	+	
Mesocyclops leuckarti (Claus, 1857)	+	+	+	+	+
Thermocyclops oithonoides (Sars, 1863)	+	+	+	+	+
Thermocyclops crassus (Fischer, 1853)	+	+	+	+	+
Number of species:	30	27	19	16	23

In 1985-87, great planktonic crustacean communities were only formed in the middle part of the lake and in the cassette. In contrast, from 1988 number of individuals exhibited no decreases in the southern parts either, obviously owing to the drastic diminishing of the stands of aquatic macrophytes.

On the basis of planktonic crustacean biomass, the water of this lake was eutrophic or even hypertrophic during most of the year. Number of individuals did not decrease even during *Aphanisomenon* and *Microcystis* blooms lasting for several months.

In samples collected with funnel traps, species compositions of communities also exhibited spatial and temporal changes. Kelso & Ney (1985) have observed in a Virgininian reservoir, that until July species typical of open water dominated, and later species living among aquatic plants attained preponderance. No such changes were observed in this lake during this two-year study, and on each occasion *Acanthocyclops robustus* f. *limnetica*, the most conspicuous member of the plankton, dominated.

Collections with funnel traps were also made in three different basins of Lake Balaton (Forró 1992). These collections differed in taxonomical composition. Among crustaceans, species of Ostracoda and Amphipoda also occurred in greater individual number. The fact that the epibenthic crustacean fauna in the Hídvégi-tó, which is constructed in the vicinity of Lake Balaton, is different from that of found in Lake Balaton could be explained; besides other basic differences between them; by the age differences of the two lakes. The few years which have passed since the construction of this lake were not sufficient to produce corresponding communities.

This statement is also supported by the fact that the abundances found by means of funnel traps in this first stage of the Kis Balaton Protective System were very small. The values obtained were much lower than those for Lake Balaton (Forró 1992), and also fall behind those for European and North American waters (Whiteside *et. al.* 1978, Whiteside & Lindegaard 1982, Kelso & Ney 1985).

It was observed by Kelso & Ney (1985) in connection with the seasonal changes of abundance that after a maximum in July it continually decreased until November, which they explained first of all by predation. In contrast, maximum abundance was observed by Whiteside *et. al.* (1978) in early summer and in autumn. In the latter case, however, the autumn peak for species living on mud surface was less distinct compared to those living among aquatic plants. In the Hídvégi-tó, the individual number of animals collected with funnel traps from mud surface diminished both from July through October 1987 and during summer 1988. These changes are difficult to explain, and it is likely that here predation or degradation of water quality have also played an important role.

The results suggest that the trophic level of the lake is much higher as compared with the River Zala and the Bay of Keszthely. Therefore the deterioriation of water quality in Lake Balaton will not be slowed down or stopped, but even accelerated because of water input from the Hídvégi-tó.

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